
BIOGEOGRAPHY AND FLORISTIC AFFINITIES OF THE LIMESTONE FLORA IN SOUTHERN YUNNAN, CHINA¹

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ABSTRACT

The forests on limestone in southern Yunnan, in tropical southwest China, were inventoried, and their floristic composition and biogeographical affinities are discussed. These limestone forests were characterized by phanerophytes making up ca. 78% of the total species and those with mesophyllous leaves comprising 75%. Ecological species groups based on their habitat preferences were discerned from field observations: the species exclusive to the limestone habitats make up 10% and the preferents make up ca. 12% of the total limestone flora. From these limestone forests, 1394 vascular plant species belonging to 640 genera and 153 families were recorded. Based on their distributions, 12 biogeographic elements at the generic level and nine at the specific level were recognized. About 90% of the seed plant genera (over 90% of the species) were tropical; furthermore, 35% of the seed plant genera (65% of the species) have tropical Asian affinities. In a comparison with other regional floras from southern China and tropical Asia, the limestone flora of southern Yunnan revealed closer affinity to tropical floras than to temperate elements of eastern Asian floras. This limestone flora is thus tropical and part of the tropical Asian flora at its northern margin.

Key words: biogeography, China, limestone forest, southern Yunnan.

Limestone in tropical China occurs mainly in Yunnan and Guangxi Provinces of southern and central China. Because of the great diversity of edaphic conditions and topography, vegetation types on limestone are extremely diverse and rich in endemic taxa. Limestone vegetation in southern China has been destroyed as much as other vegetation types even though these limestone areas are more difficult to access and to farm. Limestone vegetation is also more vulnerable because it recovers much more slowly on usually thin soils. Our research was conducted mainly in the area of Xishuangbanna, in the southern part of Yunnan, where about 19% (3600 km²) of the total area is limestone (Liu et al., 1990). Most of this limestone area is still forested and is receiving increasing attention for its biodiversity and its urgent need of conservation. Primary floristic works in southern Yunnan have been written (Zhu et al., 1996, 1997, 1998a, 1998b; Wang et al., 1997). This paper represents a synthesis of its floristics, physiognomy, and biogeographical affinities.

GENERAL GEOGRAPHY

Xishuangbanna, the southern part of Yunnan, which borders Burma and Laos, is a mountainous area at the northern margin of tropical Southeast Asia (Fig. 1). Basically, the study area has a mountainous topography with the mountains running north-south and decreasing in elevation southward. Altitude varies from 480 m in the lowest valley in the south to 2400 m at the top of the highest mountain in the north. The limestone strata occur mainly in southeastern Xishuangbanna and range in altitude from 600 to 1600 m.

The region of Xishuangbanna has a typical tropical monsoon climate with an annual mean temperature of 22°C, annual temperature accumulation (the sum of daily temperature means where they are > 10°C) of 8000°C, and annual precipitation varying from 1200 to 1556 mm, of which more than 80% falls during the rainy season between May and the end of October (Xu et al., 1987).

The rock substrate is hard limestone of Permian origin with a rugged topography. The soil is mainly

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


Figure 1. Locations of the research area in Xishuangbanna, southern Yunnan, China, and compared regional floras (see Table 6). —1. Our research area. —2. Longgan, SW China. —3. Daqinshan Mountains, SW China. —4. Gulinqing, SW China. —5. Huapin, China. —6. Dongyang Mountains, China. —7. Cucphuong, N Vietnam. —8. Chiengdao, N Thailand. —9. The Malay Peninsula. —10. Taiping, Malaya Peninsula.

brown, coarse in texture, and composed of loamy limestone with a pH of ca. 6.75 and ca. 3.56% organic matter (Liu et al., 1990).

METHODS

A complete floristic inventory was made based on the identification of more than 5000 plant specimens collected from the limestone habitat in southern Yunnan during 1985–1995 and deposited mainly at HITBC and SYS. The flora of the vegetation on the limestone consisted of 153 families of vascular plants, including 640 genera and 1394 species. An initial floristic analysis was made based on the inventory (Zhu et al., 1996). Three main vegetation types occur on the limestone—tropical seasonal rain forest, tropical seasonal moist forest, and tropical montane dwarf forest—which were selected for establishing plots. For the tropical seasonal rain forest, seven separate plots ranging in size from 2000 to 2500 m² were established. For the tropical seasonal moist forest seven separate plots ranging in size from 500 to 2000 m² were laid out. For the tropical montane dwarf forest, only two plots of 10 by 10 m were made due to its restriction to limestone summits. These different plot sizes were used because of the differential coverage of forest type and site restrictions. The structure and species composition of the vegetation on the limestone were analyzed based on plot data already published (Zhu et al., 1998a). In the present paper, plant inventory lists of the two main forest types (excluding montane dwarf forest) were compiled from sample plots separately for the physiognomic (life form and leaf size) analysis. The criteria for life form and leaf size classes suggested by Raunkiaer (1934) and the importance value index (IVI) suggested by Curtis and McIntosh (1951) were used in the physiognomic or ecological analysis. Ecological species groups were discriminated from field observation and correspond to groups used in Shimizu (1964) and Chin (1977). Species-level biogeographical affinities were assessed for the total flora of the limestone vegetation. The floristic similarities between the limestone flora of southern Yunnan and the floras on limestone and non-limestone habitats from southwest China, northern Vietnam, northern Thailand, and the Malay Peninsula were also discussed.

CLASSIFICATION OF LIMESTONE VEGETATION

Based on plant physiognomy, forest profile, floristic composition, and habitat, the primary limestone vegetation can be classified into three vegetation types, i.e., tropical seasonal rain forest,

tropical seasonal moist forest, and tropical montane dwarf forest (Zhu et al., 1998a). Within these, six formations, including nine communities, were recognized:

- (1) Ravine seasonal rain forest (including the *Pometia tomentosa*–*Alphonsea monogyna* community and *Pometia tomentosa*–*Celtis philippensis* var. *wightii* community);
- (2) Lower hill seasonal rain forest (including only the *Celtis philippensis* var. *wightii*–*Lasiococca comberi* var. *pseudoverticillata* community);
- (3) Evergreen moist forest (including the *Osmanthus polyneurus*–*Dracaena cochinchinensis* community and *Lasiococca comberi* var. *pseudoverticillata*–*Cleistanthus sumatratus* community);
- (4) Semi-evergreen moist forest (including the *Bombax insignis*–*Colona floribunda* community and *Bombax insignis*–*Garcinia bracteata* community);
- (5) Evergreen dwarf forest (including only the *Photinia angusta*–*Pistacia weinmannifolia* community);
- (6) Semi-evergreen dwarf forest (including only the *Ficus nerifolia*–*Dracaena cochinchinensis* community).

Detailed descriptions and ecological analyses of the communities have been reported earlier (Zhu et al., 1998a). Here the classification of the limestone vegetation is concisely enumerated so that the biogeographical components of the limestone vegetation can be better understood.

TROPICAL SEASONAL RAIN FOREST

Tropical seasonal rain forest on limestone, just as the regional tropical seasonal rain forest off limestone, shares characteristics with the equatorial lowland rain forest. These forests are mainly evergreen, but there are some deciduous trees in the emergent layer. This is equivalent to the tropical semi-evergreen rain forest of Southeast Asia (Whitmore, 1984), or the tropical semi-evergreen forest of India–Burma (Champion, 1936), as well as the evergreen seasonal forest of tropical America (Beard, 1944, 1955). In southern Yunnan, these limestone forests occur in wet valleys and on lower slopes of hills or mountains below 1000 m altitude. This same forest type also occurs in northern Thailand (Smitinand, 1966) and North Vietnam (Thin, 1997), although different names were used. The tropical seasonal rain forest represents Southeast Asian tropical rain forest at its latitudinal and altitudinal limits. The ecological structure of the tropical seasonal rain forest on limestone is almost exactly the same as the seasonal rain forest off limestone in the Xishuangbanna region (Zhu, 1992,

Table 1. Life forms of the limestone forest in southern Yunnan.

Life form*	Liana						Phanerophytes						Therophytes		
	Para	Epiph	Woody	Herb	Megaph	Mesoph	Nanoph	Hph	All	Cham	Geoph	phytes			
Limestone seasonal rain forest (14800 m ² of 7 plots, total 249 species)	Number of species	1	7	48	3	9	84	34	17	12	156	31	3	—	—
	Percentage of total species	0.4%	2.8%	19.3%	1.2%	3.6%	33.7%	13.7%	6.8%	4.8%	62.7%	12.4%	1.2%	—	—
Limestone seasonal moist forest (9650 m ² of 7 plots, total 211 species)	Number of species	—	18	27	5	2	62	36	21	3	124	28	7	2	0.9%
	Percentage of total species	—	8.5%	12.8%	2.3%	0.9%	29%	17%	9.9%	1.4%	58.8%	13%	3.3%	0.9%	—

* Life form (Raunkiaer, 1934); Megaph = Megaphanerophyte (perennials over 30 m high); Mesoph = Mesophanerophyte (perennials 8 to 30 m high); Nanoph = Nanophanerophyte (perennials 0.25 to 2 m high); Hph = Herbaceous phanerophyte (herbaceous perennials, dying back above ground); Geoph = Geophyte (perennials, dying back above ground); Para = Parasitic; Epiph = Epiphytes; Therophytes = Chamaephytes (perennials less than 0.25 m high above ground) (annuals).

1997). Most species in the seasonal rain forest on limestone are also found in the adjacent non-limestone seasonal rain forest, but the latter is more diverse with additional species, which are not found on the limestone.

TROPICAL SEASONAL MOIST FOREST

Tropical seasonal moist forest occurs on the middle and upper limestone slopes ranging from 650 to 1300 m altitude. This vegetation type abuts the seasonal rain forest and was called monsoon forest by some Chinese authors (Liu, 1987; Wu, 1980). The term seasonal moist forest is preferred here because the forest is not equivalent to Schimper's monsoon forest (Schimper, 1903), in spite of the fact that it is affected by seasonal dryness and contains a variable percentage of deciduous trees. The seasonal dryness in the region is compensated to some extent by dense fog accompanied by low temperatures in the same months (November to April) (Whitmore, 1984). Some deciduous trees, such as *Gmelina arborea* Roxb., *Anthocephalus chinensis* (Lam.) Rich. ex Walp., and *Homalium laoticum* Gagn. var. *glabretum* C. Y. Wu, shed leaves toward the end of the dry season, while others, such as *Cratoxylon cochinchinensis* (Lour.) Bl., *Ficus religiosa* L., and *Elaeocarpus varunua* Buch.-Ham. ex Mast., shed their old leaves as new ones develop. This suggests that deciduousness in the region is more frequently associated with locally dry habitats than the seasonal dryness of climate. Therefore, using the term monsoon forest for the evergreen or semi-evergreen forest on limestone is confusing because Schimper's monsoon forest is more or less completely leafless during the dry season.

MONTANE DWARF FOREST

Montane dwarf forest occurs only on the tops of hills and summits of mountains at altitudes above 900 m. There is only one dwarf tree layer with a canopy height of 7–15 m. Epiphytic orchids, such as *Eria hainanensis* Rolfe and *Bulbophyllum nigrescens* Rolfe, and non-vascular epiphytes (bryophytes and lichens) are abundant. In some sites small woody climbers, such as *Derris caudatilimba* How (Papilionaceae) and *Pristimera arborea* (Roxb.) A. C. Smith (Hippocrateaceae), are also frequent.

PLANT PHYSIOGNOMY OR ATTRIBUTES

From plot data, life form spectra (Raunkiaer, 1934) of the two main forest types (seasonal rain forest and seasonal moist forest) are compiled in

Table 2. Physiognomic characteristics of the limestone forest in southern Yunnan.

Forest type		Leaf form		Leaf texture		Leaf size			
		S	C	P	L	Na	Mi	Me	Ma
Limestone seasonal rain forest ¹	Percentage of species	72.3	27.7	47.9	52.1	0	13.8	76.6	9.6
	Percentage of Importance Value Index (IVI) ³	76.3	23.7	52.8	47.2	0	3.8	91	5.3
Limestone seasonal moist forest ²	Percentage of species	68	32	51.5	48.5	1	21.5	74.2	3.1
	Percentage of Importance Value Index (IVI)	74.8	25.2	41.7	58.3	0.4	23.3	66.5	9.7

¹ From 14800 m² of 7 plots, total of 94 tree species > 5 cm DBH.² From 9650 m² of 7 plots, total of 97 tree species > 5 cm DBH.³ IVI = Relative dominant density + Relative frequency + Relative dominant breast area (Curtis & McIntosh, 1951).S: Simple leaves; C: Compound leaves; P: Papery leaves; L: Leathery leaves; Ma: Macrophyll (large to 164,025 mm²); Me: Mesophyll (to 18,222 mm²); Mi: Microphyll (to 2025 mm²); Na: Nanophyll (to 225 mm²) (Raunkiaer, 1934).

Table 1. Leaf size spectra, leaf form, and leaf texture are shown in Table 2. Both forest types were dominated by phanerophytes. Including lianas, these perennial phanerophytes make up 73.9–83.2% of the total species, while annual chamaephytes account for only 12.4–13%. However, the seasonal moist forest shows lower percentages of woody lianas as well as megaphanerophytes and mesophanerophytes, but higher percentages of epiphytes as well as microphanerophytes and nanophanerophytes than the seasonal rain forest.

Both forest types have species with mesophyllous leaves making up ca. 75% of the total tree species, but the forests show clear differences if the species are weighted by importance value index (IVI). This increases the percentage of mesophyllous perennials and decreases the percentage of micro- and macrophyllous trees in seasonal rain forest, while the opposite trend is seen in seasonal moist forest. Seasonal moist forest occupies much more rugged habitats with thinner and drier soils, and has more microphyllous species. In weighting by IVI, the increase in percentage of macrophyllous trees in seasonal moist forest is mainly due to the dominant evergreen species *Dracaena cochinchinensis* (Lour.) S. C. Chen (Agavaceae), with its long leathery lanceolate leaves, and the dominant deciduous tree species *Colona floribunda* (Wall. ex Voigt) Craib (Tiliaceae) also with large leaves to 30 cm long. In

weighting the species by IVI, the percentage of leathery leaves decreases in seasonal rain forest but increases in seasonal moist forest due to the presence of some species with these leathery leaves such as *Cleistanthus sumatranus* (Miq.) Muell.-Arg. (Euphorbiaceae) and *Dracaena cochinchinensis*.

ECOLOGICAL SPECIES GROUP

Based on the study of the limestone floras of Japan and Taiwan, Shimizu (1964) divided limestone plants into five ecological groups:

- (1) plants exclusive to limestone habitat;
- (2) plants selective for and found mainly in limestone;
- (3) plants preferring and dominant on limestone;
- (4) taxa indifferent, with no special association with limestone;
- (5) plants found only occasionally on limestone or strangers to limestone.

To Shimizu, these first three groups were characteristic species for the limestone habitats and in particular his exclusive and selective taxa were calcicoles. Chin (1977) accepted this classification and similarly categorized plants on limestone in the Malay Peninsula into four groups, combining selective and preferent plants. Similar ecological species groups have been later recognized by Chinese botanists (Liang et al., 1985; Liu et al., 1994).

Table 3. The ecological species groups of the limestone flora of southern Yunnan.

Ecological species groups (see Shimizu, 1964; Chin, 1977)	Number of species	%
Plants found only on limestone: endemic to southern Yunnan	24	1.7
not endemic to southern Yunnan	117	8.4
Plants dominant on limestone	170	12.2
Plants no restriction on limestone	858	61.6
Plants found occasionally on limestone	225	16.1
Total	1394	100

Table 4. Predominant families found in limestone forests of southern Yunnan.

	No. of genera	No. of species	%*		No. of genera	No. of species	%
Orchidaceae	35	86	26.9	Verbenaceae	6	20	43.5
Rubiaceae	34	58	64.1	Labiatae	13	20	30.1
Euphorbiaceae	27	58	60.4	Gesneriaceae	13	19	63.3
Papilionaceae	22	55	43.4	Sterculiaceae	7	18	46.8
Moraceae	7	48	73.8	Dioscoreaceae	1	18	64.3
Vitaceae	7	38	79.5	Menispermaceae	10	17	60.7
Acanthaceae	26	36	65.4	Liliaceae	10	16	64.0
Rutaceae	11	35	71.4	Araceae	10	15	44.1
Asclepiadaceae	16	35	53.0	Compositae	8	15	14.6
Urticaceae	12	35	53.0	Myrsinaceae	4	14	38.2
Lauraceae	10	35	45.0	Commelinaceae	7	14	60.9
Apocynaceae	19	33	58.9	Zingiberaceae	6	14	42.4
Meliaceae	12	30	83.0	Myrtaceae	1	13	45.8
Annonaceae	12	30	50.9	Tiliaceae	3	12	57.1
Cucurbitaceae	9	24	52.3	Mimosaceae	6	12	66.6
Rhamnaceae	19	21	70.4	Anacardiaceae	7	11	64.7
Piperaceae	3	20	54.8	Convolvulaceae	4	11	37.4
				Ulmaceae	5	11	100

$$* \% = \frac{\text{the no. of species on limestone}}{\text{the total no. of species in southern Yunnan}} \times 100$$

Following Shimizu and Chin's classifications, we divided the limestone flora of southern Yunnan into these four ecological species groups (Table 3). In our study, 141 vascular plant species are restricted to limestone habitats and thus are exclusively found here. These include the following common species *Celtis philippensis* var. *wightii*, *Amoora calcicola*, *Murraya tetrameria*, *Pistacia weinmannifolia*, as well as species in *Agapetes*, *Sageretia*, *Tupistra*, and *Pristimera*. Of these, 24 species are endemic to southern Yunnan. Taxa exclusive to limestone make up about 10% of the total limestone flora, which agrees with the results from Longgan limestone (exclusive taxa, 13%) (Liang et al., 1985) and Longhua limestone (exclusive taxa, 10%) (Liu et al., 1994) from Guangxi Province in China. Both the exclusive and preferential taxa make up 22.3% of the total sum. They could be termed as characteristic species for limestone habitats (see Appendix 1). This is similar to the results from Longgan in Guangxi (with these characteristic species making up 20% of the total sum) (Liang et al., 1985) and from the Malay Peninsula (27.5%) (Chin, 1977).

THE FLORA AND ITS BIOGEOGRAPHY

In the limestone forests of southern Yunnan, China, 153 families of vascular plants including 640 genera and 1394 species and varieties, were recorded, of which seed plants compose 129 families, 558 genera, and 1269 species (see Appendix 1).

More than 80% of the species also occur in the non-limestone habitats of the Xishuangbanna region.

The limestone flora makes up about one quarter of the total species of the regional flora. (The flora of the Xishuangbanna region was primarily documented with 3336 native species of 1218 genera and 207 families of seed plants; see Li, 1996.) Some families show relative preference for limestone habitats (with more than 60% of the total number of species in the region on limestone), for example, Acanthaceae, Euphorbiaceae, Gesneriaceae, Meliaceae, Menispermaceae, Moraceae, Rhamnaceae, Rubiaceae, Rutaceae, Vitaceae, and Ulmaceae (Table 4). Other families, such as Hippocrateaceae, Icacinaceae, and Vacciniaceae, show an even stronger preference for limestone (found almost exclusively in limestone habitats in southern Yunnan), although they are not among the predominant families in species richness.

The distribution types of Chinese seed plants at the generic level were documented by Wu (1991). Based on Wu's document, 544 of the 558 genera of seed plants from the limestone forest of southern Yunnan can be divided into 12 distribution types or geographic elements (14 genera, which are cosmopolitan in distribution, are not included in the geographic statistics). One thousand two hundred forty-four of the 1269 species of seed plants from the limestone forest can be recognized in nine dis-

Table 5. Geographic affinities of the limestone forests of southern Yunnan.

Geographic element at the generic level (see Wu, 1991)	Percentage of genera	Geographic elements at the specific level	Percentage of species
1. Pantropic	21.1%	1. Pantropic	0.6%
2. Tropical Asia-Tropical America disjunct	2.9%	2. Tropical Asia-Tropical America disjunct	0.2%
3. Old World Tropics	13.8%	3. Old World Tropics	0.4%
4. Tropical Asia to Tropical Australia	9.0%	4. Tropical Asia to Tropical Australia	3.2%
5. Tropical Asia to Tropical Africa	7.9%	5. Tropical Asia to Tropical Africa	1.3%
6. Tropical Asia	35.3%	6. Tropical Asia (64.5%)	17.0%
7. Northern Temperate	2.8%	6a. India-Malaysia	7.3%
8. Temperate Eastern Asia and Northern America disjunct	2.8%	6b. Mainland Southeastern Asia to Malaysia	19.9%
9. Old World Temperate	0.9%	6c. Southern Asia to Mainland Southeastern Asia	20.3%
10. Temperate Mediterranean, Western Asia to Central Asia	0.2%	6d. Mainland Southeastern Asia to Southern China	0.5%
11. Eastern Asia	2.9%	7. Eastern Asia	10.6%
12. Endemic to China	0.4%	8. Southern China	18.6%
Total of 544 genera	100%	9. Endemic to Yunnan	
		Total of 1244 species	

tribution types based on their geographic distribution (25 species of seed plants are not included due to insufficient distribution references) (Table 5). At the generic level, the geographic elements of tropical distribution (1–6, Table 5) compose 90% of the total genera; the geographic elements of temperate distribution (7–10, Table 5) make up only 6.7%. At the specific level, the species that are of typical tropical distribution (1–6, Table 5) account for 70.2% of the total species. Among these, the geographic types that are considered to be from tropical Asia make up 64.5% of the total species from limestone forests in Xishuangbanna. If the species from the tropical areas adjacent to Xishuangbanna from southern China and Yunnan are included, these tropical species compose more than 90%. This indicates that the limestone flora at Xishuangbanna is principally tropical in nature and represents the tropical Asian flora at its northern tropical margin.

In a floristic comparison with nine similar floras, both limestone and non-limestone, from southwest China, northern Vietnam (Thin, 1997), northern Thailand (Smitinand, 1966), and the Malay Peninsula (Chin, 1977, 1979; Burkill & Henderson, 1925) (Table 6), the limestone flora of southern Yunnan displays explicit taxonomic affinities to the tropical floras and shows a closer affinity to the floras from the Malay Peninsula than to other floras from subtropical China (the floras of Huapin and Dongyang, see Li et al., 1986; Xu, 1984), even though these Malaysian floras lie farther away geographically from southern Yunnan. Our limestone flora in southern Yunnan shares the most genera with the limestone flora of northern Vietnam (Cuc-phuong, see Thin, 1997) among those floras compared in this study. The similarity at the generic level between our limestone flora and the limestone flora of northern Thailand (Doi Chiengdao) (Smitinand, 1966) is less than would be expected from its geographic proximity. This lack of correspondence could be because the plant list for Doi Chiengdao used here for comparison is an incomplete one consisting of only 512 species, less than half reported for most other sites in Table 6. The limestone flora of Xishuangbanna did not show a higher floristic similarity to other regional limestone floras than to non-limestone floras in our comparison. It appears that limestone floras develop from local or regional floras, supported also by the fact that only about 10% of the total species of limestone floras (the exclusive group) are restricted to limestone habitats in our study.

The floristic relationships between our limestone flora in southern Yunnan and neighboring floras of

Table 6. Comparison of floristic similarities between the limestone habitats of Xishuangbanna, southern Yunnan, and the limestone and non-limestone habitats from southwestern China and southeastern Asia.

Location	Habitat	Size of flora (Seed plants)	Shared taxa by both floras	Similarity coefficients
2. Longgan, SW China 22°14'–33°N, 106°46'E	limestone	149 families 669 genera 1363 species	118 371	91.2 66.5
3. Daqinshan Mountains, SW China 22°14'N, 107°E	non-limestone	182 fam. 871 gen. 1813 spp.	126 389	97.4 69.8
4. Gulinqing, SW China 22°36'N, 104°E	limestone	143 fam. 496 gen. 1095 spp.	116 261	89.9 52.6
5. Huapin, SW China 25°31'–39'N, 109°50'E	non-limestone	151 fam. 475 gen. 1051 spp.	83 150	72.8 33.2
6. Dongyang Mountains, SW China 25°14'N, 107°56'E	limestone	116 fam. 367 gen. 736 spp.	86 153	73.7 41.6
7. Cucphuong, N Vietnam 20°14'–24'N, 105°24'–44'E	limestone	167 fam. 860 gen. 1661 spp.	120 428	93 76.7
8. Chiendae, N Thailand 19°2'N, 98°54'E	limestone	101 fam. 342 gen. 512 spp.	93 181	92.1 52.9
9. Malay peninsula limestone 1°–6°N, 100°–104°E	limestone	117 fam. 535 gen. 1112 spp.	93 244	81.6 51.6
10. Taiping, Malay peninsula 4°N, 101°E	non-limestone	115 fam. 682 gen. 1939 spp.	94 243	82.5 51.6

Notes: The direct comparison of species composition between the different floras is not very significant before the local floras are updated and the taxa revised; therefore, the comparison of floristic similarities between the different floras at the specific level is not made.

References: location 2 (Chen, 1985); 3 (Daqinshan Forest station of Guanxi Forestry Bureau, 1980); 4 (Li, 1987); 5 (Li et al., 1986); 6 (Xu, 1984); 7 (Thin, 1997); 8 (Smitinand, 1966); 9 (Chin, 1977, 1979); 10 (Burkill & Henderson, 1925).

tropical Asia and southern China were discussed by Zhu (1997). This limestone flora shares all families and 88% of its genera with the flora of Indochina (Lecomte, 1907–1951; Aubréville et al., 1960–1996), 96% of its families and 68% of its genera with the flora of the Malay Peninsula (Ridley, 1967; Keng, 1978), 73% of its woody plant genera with Burma (Kurz, 1877), and more than 97% of its families and more than 80% of its genera with other tropical floras of south China (including Hainan Island; see Wu, 1994). The limestone flora of Xishuangbanna demonstrates strong affinity to other tropical Asian floras.

Literature Cited

- Aubréville, A., N. L. Tardieu-Blot & J. E. Vidal (editors). 1960–1996. *Flora du Cambodge, du Laos et du Vietnam*. No. 1–28. Museum National d'Histoire Naturelle, Paris.
- Beard, J. S. 1944. Climax vegetation in tropical America. *Ecology* 25: 127–158.
- . 1955. The classification of tropical American vegetation types. *Ecology* 36: 359–412.
- Burkill, I. H. & M. R. Henderson. 1925. The flowering plants of Taiping, in the Malay Peninsula. *Gard. Bull. Straits Settlem.* 3: 300–459.
- Champion, H. G. 1936. A preliminary survey of the forest types of India and Burma. *Indian Forest Rec.*, n.s. 1: 1–286.
- Chen, F. P. 1985. Limestone Flora in Longgang, Guangxi, China. Unpublished M.S. Thesis, Zhongshan University. [In Chinese.]
- Chin, S. C. 1977, 1979. The limestone hill flora of Malaya, I, II. *Gard. Bull. Singapore* 30: 165–219; 32: 64–203.
- Curtis, J. T. & R. P. McIntosh. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. *Ecology* 32: 467–496.
- Daqinshan Forest station of Guanxi Forestry Bureau. 1980. Plant list of Daqinshan, Guangxi. [Unpublished manuscript, in Chinese.]
- Keng, H. 1978. *Orders and Families of Malayan Seed Plants*. Singapore Univ. Press, Singapore.

- Kurz, W. S. 1877. Forest Flora of British Burma 1 & 2. Office of the Superintendent of Government Printing, Calcutta. [Reprint 1974, International Book Distributors.]
- Lecomte, H. (editor). 1907–1951. Flora generale de L'Indochine. Tome 1–7. Masson et Cie Editeurs, Paris.
- Li, B. 1987. Flora of Gulinqing Nature Reserve in southeastern Yunnan. Unpublished M.S. Thesis, Zhongshan University. [In Chinese.]
- Li, S. K., S. F. Yuan, L. F. Liu & Z. Z. Chen. 1986. The flora of Huapin. In: Reports on the Huapin Forest Area in Guangxi. Shandong Science Press, Jinan. [In Chinese.]
- Li, Y. H. (editor). 1996. List of Plants in Xishuangbanna. Yunnan National Press, Kunming. [In Chinese.]
- Liang, C. F., J. Y. Liang & L. F. Liu. 1985. A report on the exploration of the flora of Longgang. Guihaia 5(3): 191–209. [In Chinese with English abstract.]
- Liu, L. H. 1987. Rain forest. In: C. Y. Wu (editor), Vegetation of Yunnan. Science Press, Beijing. [In Chinese.]
- Liu, L., Y. T. Hu, Y. C. Yang, W. W. Liu & R. X. Guo (editors). 1990. Reports on Land and Economy of Xishuangbanna. Yunnan People's Press, Kunming. [In Chinese.]
- , H. Ye, G. Zhang & H. Chen. 1994. Floristic analysis of the Longhua natural reserve. Acta Bot. Austro-sinica 9: 1–16. [In Chinese with English abstract.]
- Raunkiaer, C. 1934. The Life Forms of Plants and Statistical Plant Geography. Oxford Univ. Press, Oxford.
- Ridley, H. N. 1967. The Flora of Malay Peninsula, I–V. L. Reeve, London. [Reprint.]
- Schimper, A. F. W. 1903. Plant-Geography upon a Physiological Basis. Oxford Univ. Press, Oxford.
- Shimizu, T. 1964. Studies on the limestone flora of Japan and Taiwan. Part II. J. Fac. Textile Sci. Technol. Shinsu Univ., A 12: 1–88.
- Smitinand, T. 1966. The vegetation of Dao Chiengdao, a limestone massive in Chiengmai, north Thailand. Nat. Hist. Bull. Siam Soc. 21(1–2): 93–128.
- Thin, N. N. 1997. The vegetation of Cuephuong national park, Vietnam. Sida 17: 719–759.
- Wang, H., H. Zhu & B. G. Li. 1997. Vegetation on limestone in Xishuangbanna, southwest China. Guihaia 17: 101–117. [In Chinese with English abstract.]
- Whitmore, T. C. 1984. Tropical Rain Forests of the Far East, 2nd ed. Clarendon Press, Oxford.
- Wu, C. Y. (editor). 1980. Vegetation of China, pp. 363–397. Science Press, Beijing. [In Chinese.]
- . 1991. The areal-types of Chinese genera of seed plants. Acta Bot. Yunnan Suppl. IV: 1–139.
- Wu, T. L. (editor). 1994. A Checklist of Flowering Plants of Islands and Reefs of Hainan and Guangdong Province. Science Press, Beijing. [In Chinese.]
- Xu, Y. C., H. Q. Jiang & F. Quan (editors). 1987. Reports on the Nature Reserve of Xishuangbanna. Yunnan Sci. & Techn. Press, Kunming. [In Chinese.]
- Xu, Z. R. 1984. Limestone Flora of Dongyang Mountain in Libo, Guizhou, China. Unpublished M.S. Thesis, Zhongshan University. [In Chinese.]
- Zhu, H. 1992. Tropical rain forest vegetation in Xishuangbanna. Chin. Geogr. Sci. 2: 64–73.
- . 1997. Ecological and biogeographical studies on the tropical rain forest of south Yunnan, SW China with a special reference to its relationship with rain forests of tropical Asia. J. Biogeogr. 24: 647–662.
- , H. Wang, B. G. Li & Z. F. Xu. 1996. A phyogeographical research on forest flora of limestone hills in Xishuangbanna. Guihaia 16: 317–330. [In Chinese with English abstract.]
- , —, — & —. 1997. Floristic relationships between the limestone flora of Xishuangbanna and neighboring floras of tropical Asia and south China. Acta Bot. Yunn. 19: 357–365. [In Chinese with English abstract.]
- , H. Wang & B. G. Li. 1998a. The Structure, Species Composition and Diversity of the Limestone Vegetation in Xishuangbanna, SW China. Gard. Bull. Singapore 50: 5–33.
- , H. Wang, B. G. Li & Z. F. Xu. 1998b. Research on the tropical seasonal rainforest of Xishuangbanna, south Yunnan. Guihaia 18: 371–384. [In Chinese with English abstract.]

Appendix 1. Ecological species groups of the limestone vegetation in southern Yunnan. *Flora Reipublicae Popularis Sinicae* is the authoritative source for specific and infraspecific names except for ones recently revised and in IPNI (www.ipni.org) and TROPICOS (<http://mobot.org/W3T/Search/vast.html>). The family names of angiosperms are according to the Angiosperm Phylogeny Website (<http://www.mobot.org/MOBOT/research/APweb/>).

Seed Plant Taxa exclusive to limestone habitats and endemic to southern Yunnan

ACANTHACEAE

Baphicacanthus multibracteolata H. T. Chang & H. Chu

AGAVACEAE

Dracaena menglaensis G. Z. Ye

ALANGIACEAE

Alangium kurzii var. *pachyphyllum* W. P. Fang & H. Y. Su

DIOSCOREACEAE

Dioscorea menglaensis H. Li

EBENACEAE

Diospyros atrotricha H. W. Li

EUPHORBIACEAE

Croton yanhuui Y. T. Chang
Trigonostemon lii Y. T. Chang

FAGACEAE

Quercus yiwiensis Huang
Ornithoboea calcicola C. Y. Wu ex H. W. Li

GESNERIACEAE

Amoora calcicola C. Y. Wu & H. Li

LAURACEAE

Lindera nacusua var. *monglunensis* H. P. Tsui
Neolitsea menglaensis Y. C. Yang & P. H. Huang

MALVACEAE

Pterospermum menglunensis H. H. Hsue
Pterospermum yunnanensis H. H. Hsue

MELIACEAE

Amoora calcicola C. Y. Wu & H. Li

PIPERACEAE

Piper mischocarpum Y. C. Tseng
(*HITBC*)
Sageretia thea var. *cordiformis* Y. L. Chen & P. K. Chou

Chu Hua 1192 (holotype, SYS)

Ye Guang-zheng 9035 (holotype, YCE; isotype, KUN)

Zhang Shun-cheng 24027 (HITBC); *Li Yan-hui* 1255 (holotype, KUN)

Pei Sheng-ji 10347 (holotype, KUN)

Li Yan-hui 4215 (holotype, KUN; isotype, HITBC)

Ch1050 (SYS); *Li Yan-hui* 03587 (holotype, KUN; isotype, HITBC)
Li Yan-hui 4576 (holotype, KUN)

Pei Sheng-ji 59-10040 (holotype, KUN)

Pei Sheng-ji 59-10072 (isotype, HITBC)

Li Yan-hui 4231 (HITBC), 386 (holotype, KUN)
Li Yan-hui 20078 (holotype, KUN; isotype, HITBC)

Ch378 (SYS); *Li Yan-hui* 4634 (holotype, KUN; isotype, HITBC)
Li Yan-hui 33830 (HITBC), 3717 (holotype, KUN); *Tao Guo-da* 13655 (HITBC)

Li Yan-hui 3712 (HITBC), 3804 (HITBC); *Pei Sheng-ji* 59-10292 (holotype, KUN)

Cai C.T. 59-10784 (holotype, KUN); *Li Yan-hui* 3771 (HITBC); *Tao Guo-da* 4177 (HITBC), 7152
(*HITBC*)
W. T. Wang 10496 (holotype, KUN)

Appendix 1. Continued.

THEACEAE*Pyrenaria menglaensis* G. D. Tao

Seed Plant Taxa exclusive to limestone habitats but not endemic to southern Yunnan

ACANTHACEAE

- Andrographis laxiflora* var. *glomeruliflora* (Bremek.) H. Chu
Daedalacanthus tetragonos T. Anders.
Pteracanthus alatus (Wall. ex Nees) Bremek.
Strobilanthes psostachys C. B. Clarke ex W. W. Smith
Thunbergia coccinea Wall.

AGAVACEAE

- Dracaena cambodiana* Pierre ex Gagnep.
Dracaena terniflora Roxb.

ANACARDIACEAE

- Pistacia weinmannifolia* Poiss. ex Franch.
Spondias lakonensis var. *hirsutus* C. Y. Wu & T. L. Ming
Toxicodendron fulvum (Craib) C. Y. Wu & T. L. Ming

ANNONACEAE

- Alphonsea boniana* Finet & Gagnep.
Alphonsea mollis Dunn
Alphonsea squamosa Finet & Gagnep.
Miliusa velutina Hook. f. & Thoms.
Mitraphora calcarea Diels ex Ast
Polyalthia petelotii Merr.

APOCYNACEAE

- Aganosma acuminata* (Roxb.) G. Don
Anodendron affine var. *pingpienense* Tsiang & P. T. Li
Cosmostigma hainanense Tsiang

ARACEAE

- Amorphophallus yunnanensis* Engl.
Gonatanthus pumilus Engl. & K. Krause
Remusatia vivipara Schott

BOMBACACEAE

- Bombax insigne* Wall.

BORAGINACEAE

- Ehretia dunniana* Lév.

Tao Guo-da 15933 (holotype, KUN; isotype, HITBC)

- Ch1193* (SYS), *Ch1219* (SYS)
Ch255 (SYS), *Ch1175* (SYS), *Ch1217* (SYS); *Tao-Guo-da* 3797 (HITBC)
Li Yan-hui 20047 (HITBC)
Li Yan-hui 4605 (HITBC)
Ch454 (SYS), *Ch1186* (SYS); *Li Yan-hui* 5190 (HITBC), 2911 (HITBC)

- Wang Hong* 3159 (HITBC), 3160 (HITBC)
Yang Zheng-hong 12178 (HITBC); *Expedition* 32120 (HITBC), 34923 (HITBC)

- Expedition* 32613 (HITBC); *Pei Sheng-ji* 10045 (HITBC); *Tao Guo-da* 1212 (HITBC)
Wang Hong 1792 (HITBC)
Pei Sheng-ji 10034 (HITBC); *Tao Guo-da* 13650 (HITBC)

- Ch56* (SYS)
Li Yan-hui 1043 (HITBC), 4610 (HITBC)
Ch815 (SYS)
Ch386 (SYS), *Ch814* (SYS), *Ch985* (SYS); *Zhu Hua* & *Wang Hong* 2416 (HITBC)
Ch545 (SYS)
Ch909 (SYS)

- Ch584* (SYS)
Ch802 (SYS), *Ch715* (SYS)
Ch870 (SYS)

- Li Yan-hui* 4225 (HITBC)
Tao Guo-da et al. 16166 (HITBC)
Expedition 10201 (HITBC)

- Tao Guo-da* 9007 (HITBC), 9008 (HITBC)

- Ch29* (SYS), *Ch373* (SYS); *Li Yan-hui* 3300 (HITBC), 3726 (HITBC)

Appendix 1. Continued.

BUXACEAE	<i>Tao Guo-da</i> 15739 (HITBC), 13691 (HITBC)
CAPPARIDACEAE	<i>Ch321</i> (SYS)
CELASTRACEAE	<i>Li Yan-hui</i> 455 (HITBC); <i>Tao Guo-da</i> 13672 (HITBC) <i>Ch1015</i> (SYS), <i>Ch1063</i> (SYS); <i>Li Yan-hui</i> 2736 (HITBC); <i>Wang Hong</i> 1573 (HITBC)
<i>Praeseneriella merrilliana</i> A. C. Smith	
<i>Praeseneriella yunnanensis</i> (Hu) A. C. Smith	
<i>Pristimera cambodiana</i> (Pierre) A. C. Smith	
<i>Pristimera setulosa</i> A. C. Smith	
COMBRETACEAE	<i>Tong Shao-quan</i> 24960 (HTBG)
<i>Anogeissus acuminata</i> Wall.	
COMPOSITAE	<i>YB004125</i> (HITBC)
<i>Pterocypselia indica</i> (L.) C. Shih	<i>Li Yan-hui</i> 3780 (HITBC); <i>Tao Guo-da</i> 13664 (HITBC)
<i>Vernonia currisii</i> Craib & Hutchison	
CONVOLVULACEAE	<i>Ch1170</i> (SYS); <i>Wang Hong</i> 2655 (HITBC) <i>Ch469</i> (SYS); <i>Zhu Pei-zhi</i> 10527 (HITBC)
<i>Porana paniculata</i> Roxb.	
<i>Porana racemosa</i> Roxb.	
<i>Tridynamia sinensis</i> (Hemsl.) G. W. Staples	
<i>Tridynamia sinensis</i> var. <i>delavayi</i> (Gagnep. & Courchet) G. W. Staples	
CRUCIFERAE	<i>Li Yan-hui</i> 4217 (HITBC)
<i>Cardamine calcicola</i> W. W. Smith	
DIOSCOREACEAE	<i>Ch845</i> (SYS)
<i>Dioscorea arachidna</i> Prain & Burkill	<i>Ch921</i> (SYS)
<i>Dioscorea aspersa</i> Prain & Burkill	<i>Ch473</i> (SYS); <i>Li Yan-hui</i> 2036 (HITBC)
<i>Dioscorea chingii</i> Prain & Burkill	<i>Ch791</i> (SYS); <i>Wang Hong</i> 3147 (HITBC)
<i>Dioscorea pulvrea</i> Prain & Burkill	
<i>Dioscorea tentaculigera</i> Prain & Burkill	<i>Pei Sheng-ji</i> 9985 (HITBC)
ERICACEAE	<i>Li Yan-hui</i> 3718 (HITBC), 2739 (HITBC)
<i>Agapetes burmanica</i> W. E. Evans	<i>Li Yan-hui</i> 3719 (HITBC)
<i>Agapetes lobbii</i> C. B. Clarke	<i>Li Yan-hui</i> 3629 (HITBC)
<i>Agapetes mannii</i> Hemsl.	
EUPHORBIACEAE	<i>Li Yan-hui</i> 3095 (HITBC), 2529 (HITBC)
<i>Cleistanthus sumatranaus</i> (Miq.) Muell.-Arg.	<i>Ch179</i> (SYS)
<i>Croton argyrratus</i> Blume	<i>Ch563</i> (SYS), <i>Ch812</i> (SYS)
<i>Phyllanthus clarkei</i> Hook. f.	<i>Ch367</i> (SYS), <i>Ch39</i> (SYS), <i>Ch353</i> (SYS)
<i>Trigonostemon bonianus</i> Gagnep.	

Appendix 1. Continued.

FABACEAE

- Albizia odoratissima* (L.) Benth.
Bauhinia carcinophylla Merr.
Caesalpinia tsoongii Merr.
Callerya eurybotrys (Drake) A. M. Schot
Derris caudatilimba How
Miletia tetraptera Kurz
Sophora praeteri Prain
Sophora tonkinensis Gagnep.

FUMARIACEAE

- Corydalis taliensis* var. *siamensis* (Craib) X. Zhang

GESNERIACEAE

- Raphiocarpus begoniifolius* (H. Lév.) B. L. Burtt
Didymocarpus margaritae W. W. Sm.
Lysionotus serratus D. Don
Ornithoboea henryi Craib

GUTTIFERAE

- Garcinia bracteata* C. Y. Wu ex Y. H. Li

ICACINACEAE

- Gomphandra tetrandra* (Wall.) Sleum.

LABIATAE

- Coleus xanthanthus* C. Y. Wu & Y. C. Huang
Gomphostemma pariflorum Wall.
Rabdosia eriocalyx var. *laxiflora* C. Y. Wu & H. W. Li

LAMIACEAE

- Symploisma involucratum* Roxb.

LAURACEAE

- Cryptocarya acutifolia* H. W. Li

LINACEAE

- Reinwardtia indica* Dum.

MALVACEAE

- Pterospermum chingtungense* C. Y. Wu & Hsue
Pterospermum proteus Burkil

LIANEAE

- Li Yan-hui 1411* (HTB)

LYTHRACEAE

- Ch1097* (SYS)
Ch118 (SYS)

MELIACEAE

- Li Yan-hui 4200* (HTB)
Ch398 (SYS), *Ch504* (SYS)

MELIACEAE

- Li Yan-hui 4100* (HTB)
Ch394 (SYS), *Ch559* (SYS); *Li Yan-hui 2802* (HTB), 4277 (HTB)

MELIACEAE

- Li Yan-hui 20062* (HTB), 3727 (HTB)

MELIACEAE

- Ch947* (SYS); *Pei Sheng-ji 9892* (HTB); *Tao Guo-da 15902* (HTB)
Pei Sheng-ji 1054 (HTB)
Ch624 (SYS), *Ch806* (SYS); *Pei Sheng-ji 59-9937* (HTB); *Tao Guo-da 15750* (HTB)
Expedition 32625 (HTB); *Pei Sheng-ji 59-10069* (HTB)

MELIACEAE

- Li Yan-hui 4103* (HTB), 3813 (HTB)

MELIACEAE

- Tao Guo-da 11182* (HTB)
Pei Sheng-ji 10138 (HTB)
Cui Jing-yun 14659 (HTB); *Tao Guo-da 15798* (HTB)
Li Bao-gui 9911209 (HTB); *Li Yan-hui 3759* (HTB); *Wang Zhong-yu s.n.* (HTB)

MELIACEAE

- Li Yan-hui 2988* (HTB), 4852 (HTB)

MELIACEAE

- Li Yan-hui 1029* (HTB), 3052 (HTB)

MELIACEAE

- Expedition 34310* (HTB)

- Expedition 34533* (HTB)
Li Yan-hui 3586 (HTB); *Wang Hong 831* (HTB), 842 (HTB)

Appendix 1. Continued.

MELIACEAE

Aglaia testicularis C. Y. Wu
Amoora tetrapetala (Pierre) C. Y. Wu
Munronia henryi Harms

MENISPERMACEAE

Cyclea sutchuenensis Gagnep.
Stephania chingtungensis H. S. Lo
Stephania epigaea H. S. Lo

MYRSINACEAE

Myrsine semiserrata Wall.

OLACACEAE

Nasiatopsis thunbergiaeifolia Kurz

OLEACEAE

Ligustrum sinense var. *corynanum* (W. W. Smith) Hand.-Mazz.

ORCHIDACEAE

Bulbophyllum ambrosia (Hance) Schltr.
Bulbophyllum kwangtungense Schltr.
Bulbophyllum nigrescens Rolfe
Dendrobium salaccense Lindl.
Eulophia bracteosa Lindl.
Pholidota chinensis Lindl.

PALMAE

Caryota urens L.

PIPERACEAE

Peperomia leptostachya var. *cambodiana* (C. DC.) Merr.

PRIMULACEAE

Lyssimachia garrettii Fletcher

RHAMNACEAE

Gouania javanica Miq.
Hovenia acerda var. *kiukiangensis* (Hu & Cheng) C. Y. Wu ex Y. L. Chen
Sageretia laxiflora Hand.-Mazz.
Ventilago calyculata var. *trichoclada* Y. L. Chen & P. K. Chou

Ch339 (SYS)
Ch529 (SYS); *Wang Hong* 1710 (HITBC), 1715 (HITBC)
Ch351 (SYS), *Ch192* (SYS); *Li Yan-hui* 3327 (HITBC)

Ch901 (SYS)
Tao Guo-da 43898 (HITBC)
Tao Guo-da 15672 (HITBC)

Li Yan-hui 20032 (HITBC); *Tao Guo-da* 15729 (HITBC); *Wang Hong* 1960 (HITBC)

Tao Guo-da 42370 (HITBC)

Li Yan-hui 429 (HITBC); *Tao Guo-da* 16440 (HITBC); *Wang Hong* 2101 (HITBC), 2091 (HITBC)

Ch679 (SYS)
Ch22 (SYS)
Zhu Pei-zhi 8683 (HITBC)
Ch158 (SYS)
Li Yan-hui 4150 (HITBC)
Tao Guo-da 44107 (HITBC)

Chen San-yang 18959 (HITBC)

Ch950 (SYS)

Li Yan-hui 3302 (HITBC)
Ch798 (SYS), *Ch850* (SYS); *Li Yan-hui* 3714 (HITBC)
Tao Guo-da 39915 (HITBC)
Ch399 (SYS); *Zhu Pei-zhi* 10478 (HITBC), 10479 (HITBC)
Ch550 (SYS); *Li Yan-hui* 5230 (HITBC)

Appendix 1. Continued.

RUBIACEAE

- Dannacanthus indicus* Gaertn. f.
Hymenopogon parasiticus var. *longiflorus* How ex W. C. Chen
Pavetta polyantha R. Br.
Pavetta scabrifolia Bremek.

RUTACEAE

- Murraya euchrestifolia* Hayata

SCHROPHULARIACEAE

- Lindenbergia philippinensis* (Cham. & Schltdl.) Benth.
Turpinia robusta Craib

SIMARUBACEAE

- Brucea mollis* Wall.

STAPHYLEACEAE

- Turpinia robusta* Craib

ULMACEAE

- Celtis wightii* var. *philippensis* (Planch.) E. Soepadmo

URTICACEAE

- Elatostema herbaceifolium* Hayata
Elatostema salvinoides W. T. Wang
Laportea urentissima Gagnep.
Pellionia scabra Benth.
Pilea cadierei Gagnep. & Guillaumin
Procris crenata C. B. Rob.

VERBENACEAE

- Garrettia siamensis* Fletcher

VITACEAE

- Tetrastigma cambodianum* Pierre ex Gagnep.
Tetrastigma dubium (Lawson) Planch.
Tetrastigma rupestre Planch.

ZINGIBERACEAE

- Pommereschea lackneri* Wittm.
 Seed Plant Taxa preferent to limestone habitats

- Ch361* (SYS), *Ch816* (SYS)
Tao Guo-da 13651 (HITBC)
Ch368 (SYS), *Ch270* (SYS); *Li Yan-hui* 1773 (HITBC), 4111 (HITBC)
Li Yan-hui 4240 (HITBC), 3871 (HITBC)

- Li Yan-hui* 3716 (HITBC), 3309 (HITBC); *Tao Guo-da* 15722 (HITBC); *Expedition* 32673
 (HITBC)

- Li Yan-hui* 3815 (HITBC), 4269 (HITBC)

- Ch96* (SYS); *Li Yan-hui* 363 (HITBC), 3952 (HITBC)

- Li Yan-hui* 4203 (HITBC)

- Li Yan-hui* 393 (HITBC); *Zhang Jian-hou* 13707 (HITBC)
Ch32 (SYS), *Ch371* (SYS), *Ch1089* (SYS); *Li Yan-hui* 391 (HITBC), 4211 (HITBC)

- Ch877* (SYS)
Ch879 (SYS); *Li Yan-hui* 4105 (HITBC); *Zhu Pei-zhi* 8649 (HITBC)
Li Yan-hui 396 (HITBC)
Ch917 (SYS)
Ch572 (SYS), *Ch719* (SYS)
Ch514 (SYS), *Ch632* (SYS); *Li Yan-hui* 3751 (HITBC)

- Ch358* (SYS), *Ch710* (SYS), *Ch941* (SYS)

- Ch91* (SYS), *Ch925* (SYS); *Zhang Jian-hou* 13602 (HITBC)
Li Yan-hui 3700 (HITBC), 2737 (HITBC)
Ch139 (SYS)

- Pei Sheng-ji* 10073 (HITBC); *Tao Guo-da* 44091 (HITBC)

Appendix 1. Continued.

ACANTHACEAE

- Andrographis laxiflora* (Blume) Lindau
Eranthemum pulchellum Andr.
Goldfussia glomerata Nees
Pseuderanthemum palatifolium Radlk.
Pseuderanthemum polyanthum (C. B. Clarke) Merr.
Rhipidospora vagabunda (R. Ben) C. Y. Wu
Semostachya longispicata (Hayata) C. F. Hsieh & T. C. Huang

ANNONACEAE

- Miliusa chunii* W. T. Wang
Mitrophora maingayi Hook. f. & Thoms.
Mitrophora thorelii Pierre
- APOCYNACEAE**
- Antostelma lantsangensis* (Tsiang & P. T. Li) P. T. Li
Bidaria yunnanense (Tsiang) P. T. Li
Dischidia esquirolii (Lév.) Tsiang
Dischidia minor (Vahl) Merr.
Gymnema sylvestre (Retz.) Schult.
Gymnema latifolium Wall. ex Wight
Hoya camosa (L. f.) R. Br.
Hoya lyi Lév.
Hoya nervosa Tsiang & P. T. Li
Hoya villosa Costamin.
Jasminanthes saxatilis (Tsiang & P. T. Li) W. D. Stevens & P. T. Li
Marsdenia tenacissima (Roxb.) Moon
Toxocarpus villosus (Blume) Decne.

ARACEAE

- Aglaonema pierreanum* Engl.
Colocasia gigantea Hook. f.
Raphidophora decursiva (Roxb.) Schott
Raphidophora hongkongensis Schott

BEGONIACEAE

- Begonia augastinei* Hemsl.
Begonia dryadis Imsch.
Begonia prostrata Imsch.

BOMBACACEAE

- Bombax ceiba* L.

- Ch376* (SYS); *Ch808* (SYS); *Ch974* (SYS); *Li Yan-hui* 3721 (HITBC)
Li Yan-hui 2898 (HITBC)
Ch1191 (SYS); *Tao Guo-da* 3775 (HITBC)
Ch137 (SYS); *Ch172* (SYS); *Ch180* (SYS); *Ch310* (SYS)
Ch91 (SYS); *Li Yan-hui* 1011 (HITBC)
Ch36 (SYS); *Ch247* (SYS); *Li Yan-hui* 2829 (HITBC)
Ch1182 (SYS)

- Ch499* (SYS); *Ch1211* (SYS); *Unknown coll.* 74317 (HITBC), 74318 (HITBC)
Li Yan-hui 3139 (HITBC)
Ch673 (SYS); *Ch420* (SYS); *Li Yan-hui* 67493 (HITBC)

- Ch658* (SYS)
Ch242 (SYS); *Ch764* (SYS)
Ch23 (SYS)
Ch729 (SYS)
Expedition 34523 (HITBC)
Ch586 (SYS); *Ch633* (SYS); *Ch716* (SYS); *Yang Zheng-hong* 10976 (HITBC)
Ch651 (SYS)
Tao Guo-da 35474 (HITBC)
Zhang Jian-hou 18562 (HITBC)
Ch960 (SYS); *Li Yan-hui* 2574 (HITBC)
Tao Guo-da 44195 (HITBC)
Ch438 (SYS); *Expedition 32621* (HITBC)
Ch544 (SYS); *Ch587* (SYS); *Ch646* (SYS)

- Ch233* (SYS); *Ch240* (SYS); *Pei Sheng-ji* 10274 (HITBC)
Ch1169 (SYS); *Tao Guo-da* 9123 (HITBC)
Ch1160 (SYS); *Li Jie* 722 (HITBC)
Ch706 (SYS); *Ch1179* (SYS)

- Li Yan-hui* 2946 (HITBC)

Appendix 1. Continued.

BORAGINACEAE*Ehretia tsangii* I. M. Johnst.**CAPPARIDACEAE***Caparis membranifolia* Kurz
Caparis urophylla F. Chun**CAPRIFOLIACEAE***Viburnum tsangii* Rehder**CARDIOPTERIDACEAE***Peripterygium quinquelobum* Hassk.**COMMELINACEAE***Porandra scandens* D. Y. Hong**COMPOSITAE***Youngia japonica* (L.) DC.**EBENACEAE***Diospyros yunnanensis* Rehder & Wils.**EUPHORBIACEAE***Adenochlaena silhetensis* Benth.*Antidesma montanum* var. *microphyllum* (Hemsl.) P. Hoffmann*Cleidion bracteosum* Gagnep.*Cleidion brevipetiolatum* Pax & K. Hoffm.*Lasiococca comberi* var. *pseudovernicellata* (Merr.) H. S. Ku*Sumbaviopsis albicans* (Blume) J. J. Smith**FABACEAE***Bauhinia genuflexa* Craib*Millettia yunnanensis* Pamp.*Whitfordiodendron filipes* (Dunn) Dunn**FLACOURTIACEAE***Flacourtia rukam* Zoll. & Mor.**GESNERIACEAE***Chirita dimidiata* R. Br.
Paraboea rufescens (Franch.) B. L. Burtt
Paraboea dictyoneura (Hance) B. L. Burtt
Paraboea sinensis f. *macrophylla* (Stapf) C. Y. Wu
Ch948 (SYS)
Ch379 (SYS); *Wang Hong* 2724 (HITBC)
Ch842 (SYS); *Wang Hong* 2707 (HITBC)
Ch272 (SYS); *Expedition* 34359 (HITBC); *Tao Guo-da* 16748 (HITBC), 3792 (HITBC)*Li Yan-hui* 3360 (HITBC), 3726 (HITBC)*Ch612* (SYS); *Zhao Shi-wang* 22582 (HITBC)
Ch853 (SYS), *Ch136* (SYS), *Ch153* (SYS), *Ch195* (SYS); *Li Yan-hui* 2112 (HITBC)*Li Yan-hui* 4235 (HITBC); *Zhu Pei-zhi* 10470 (HITBC)*Expedition* 34761 (HITBC)*Ch902* (SYS); *Pei Sheng-ji* 9947 (HITBC); *Unknown coll.* 262 (HITBC)*Ch1201* (SYS), *Ch326* (SYS); *Tao Guo-da* 1742 (HITBC)*Ch516* (SYS), *Ch1214* (SYS); *Cui Jing-yun* 14656 (HITBC); *Pei Sheng-ji* 10300 (HITBC)*Ch807* (SYS); *Zou Shuang-yun* 356 (HITBC)*Li Yan-hui* 3575 (HITBC)*Li Yan-hui* 4250 (HITBC)*Ch922* (SYS); *Li Yan-hui* 399 (HITBC)*Ch309* (SYS), *Ch226* (SYS), *Ch38* (SYS); *Li Yan-hui* 1694 (HITBC)*Ch131* (SYS); *Li Yan-hui* 2423 (HITBC)*Ch25* (SYS), *Ch97* (SYS); *Li Yan-hui* 1500 (HITBC)*Tao Guo-da* 13668 (HITBC)*Zhao Shi-wang* 22492 (HITBC)*Ch784* (SYS)

Appendix I. Continued.

GRAMINEAE

Dendrocalamus strictus (Roxb.) Nees

ICACINACEAE

Apodytes dimidiata E. Meyer ex Arn.

LABIATAE

Colebrookea oppositifolia Sm.

Elsholtzia stachyodes (Link) C. Y. Wu

LAMIACEAE

Clerodendron henryi Pei

Garrettia siamensis Fletcher

Premna hamiltonii J. L. Ellis

Sphenodesme mollis Craib

LAURACEAE

Litsea dillenijifolia P. Y. Bai & P. H. Huang

Litsea elongata (Wall. ex Nees) Benth. & Hook. f.

Phoebe lanceolata (Wall. ex Nees) Nees

LILIACEAE

Polygonatum punctatum Royle ex Kunth
Tupistra wattii Hook. f.

MALPIGHIAEAE

Hiptage benghalensis var. *tonkinensis* (Dop) S. K. Chen
Tupistra wattii Hook. f.

MALVACEAE

Sterculia villosa Roxb.

MELIACEAE

Chukrasia tabularia var. *velutina* King
Diospyrum lenticellatum C. Y. Wu & H. Li

Diospyrum spicatum H. L. Li

Toona ciliata var. *pubescens* (Franch.) Hand.-Mazz.

MORACEAE

Cudrania jinghongensis S. S. Chang
Ficus orthoneura Lév. & Vaniot

Ficus prostata Wall. ex Miq.

Ficus pubigera var. *maliformis* (King) Corner

MYRSINACEAE

Ardisia garrettii Fletcher

Ch1058 (SYS); *Sun Ji-liang* 18151 (HTBC)

Tao Guo-da 16690 (HTBC)

Ch51 (SYS); *Li Yan-hui* 252 (HTBC), *Sun Ji-liang* 18005 (HTBC)

Tao Guo-da 3798 (HTBC)

Wang Hong 2921 (HTBC), 2922 (HTBC), 2940 (HTBC)
Expedition 32276 (HTBC); *Unknown coll.* 2434 (HTBC), 456 (HTBC); *Wang Hong* 2727 (HTBC)

Ch177 (SYS), *Ch278* (SYS); *Expedition* 32617 (HTBC)

Ch864 (SYS)

Li Yan-hui 3053 (HTBC)
Ch269 (SYS), *Ch119* (SYS)
Ch161 (SYS), *Ch61* (SYS), *Ch324* (SYS); *Li Yan-hui* 754 (HTBC)

Ch711 (SYS)
Expedition 34321 (HTBC); *Yang Zhen-hong* 6971 (HTBC); *Wang Hong* 3102 (HTBC)

Ch45 (SYS); *Li Yan-hui* 1051 (HTBC)

Zou Shuang-yun 324 (HTBC)

L. Yan-hui 385 (HTBC)
Ch508 (SYS); *Cui Jing-yun* 22658 (HTBC)
Unknown coll. 250 (SYS)
Ch680 (SYS), *Ch566* (SYS), *Ch581* (SYS)

Li Yan-hui 3135 (KUN)
Ch41 (SYS); *Li Yan-hui* 3802 (HTBC)
Zhu Hua & *Wang Hong* 88-11 (HTBC)
Li Yan-hui 3223 (HTBC)

Ch130 (SYS), *Ch170* (SYS), *Ch47* (SYS); *Li Yan-hui* 3867 (HTBC)

Appendix 1. Continued.

MYRTACEAE
Syzygium claviflorum (Roxb.) Wall ex A. M. & J. M. Cowan*Ch501* (SYS), *Ch492* (SYS)**ORCHIDACEAE***Gastrochilus obliquus* (Lindl.) Kuntze
Nervilia plicata (Andr.) Schltr.
Tropidia angulosa (Lindl.) Blume**OROBANCHACEAE***Aeginetia indica* L.**OXALIDACEAE***Averrhoa carambola* L.
Biophytum esquirolii Lév.**PALMAE***Caryota ochlandra* Hance**PIPERACEAE***Peperomia heyneana* Miq.
Piper arboricola C. DC.
Piper curtipedunculatum C. DC.**RHAMNACEAE***Ventilago leiocarpa* var. *pubescens* Y. L. Chen & P. K. Chou
Zizyphus atopensis Pierre**RUBIACEAE***Ixora cephalophora* Merr.
Pavetta arenosa Lour.
Pavetta hongkongensis Bremek.
Psychotria pilifera Hutch.
Psychotria siamica (Craib) Hutch.
Spiradiclis caespitosa f. *subimmersa* Lo**RUTACEAE***Glycosmis citrifolia* (Willd.) Lindl.
Murraya koenigii (L.) Spreng.
Murraya microphylla (Merr. & Chun) Swingle
Murraya paniculata (L.) Jack.
Zanthoxylum armatum var. *ferrugineum* (Rehder & E. H. Wilson) C. C. Huang
Zanthoxylum laetum Drake
Zanthoxylum utile C. C. Huang
Ch222 (SYS), *Ch146* (SYS); *Zou Shuang-yun* 333 (HITBC)
Ch176 (SYS), *Ch330* (SYS), *Ch352* (SYS), *Ch313* (SYS); *Li Yan-hui* 1859 (HITBC)
Expedition 34267 (HITBC); *Tao Guo-da* 44056 (HITBC)
Li Yan-hui 3315 (HITBC)
Ch222 (SYS), *Ch146* (SYS); *Zou Shuang-yun* 333 (HITBC)
Ch176 (SYS), *Ch330* (SYS), *Ch352* (SYS), *Ch313* (SYS); *Li Yan-hui* 1859 (HITBC)
Li Yan-hui 1289 (HITBC), *Ch251* (SYS)
Ch1088 (SYS), *Ch645* (SYS)
Li Yan-hui 1289 (HITBC), *Ch251* (SYS)
Ch1218 (SYS), *Ch1229* (SYS)
Li Yan-hui 246 (HITBC), *2814* (HITBC)
Ch355 (SYS); *Zhu Hua* & *Wang Hong* 3004 (HITBC)
Ch712 (SYS), *Ch165* (SYS); *Li Yan-hui* 1498 (HITBC)
Ch836 (SYS); *Li Yan-hui* 2473 (HITBC), *258* (HITBC)
Li Yan-hui 12675 (HITBC)

Appendix 1. Continued.

STAPHYLEACEAE

Tapiscia yunnanensis W. C. Cheng & S. D. Chu

TETRAMELACEAE

Tetrameles nudiflora R. Br.

TILIACEAE

Colona floribunda (Wall.) Craib
Colona thorelii (Gagnep.) Burret

URTICACEAE

Boehmeria zollingeriana Wedd.
Debregeasia edulis (Siebold & Zucc.) Wedd.
Elaosistema rupestre (Buch.-Ham.) Wedd.
Pilea monilifera Hand.-Mazz.
Pilea plataniflora C. H. Wright
Pouzolzia sanguinea (Blume) Merr.

VITACEAE

Leea aquata L.
Yua austro-orientalis (Metcalf) C. L. Li
Tetrastigma caulinflorum Merr.
Tetrastigma delavayi Gagnep.
Tetrastigma erubescens var. *monospermum* Gagnep.
Tetrastigma pubinerve Merr. & Chun
Vitis balansaeana Planch.
Vitis betulifolia Diels & Gilg

ZINGIBERACEAE

Hedychium sino-aureum Stapf
Hedychium villosum var. *tenuiflorum* Wall. ex Baker
Pommereschea spectabilis (King & Prain) K. Schum.

Pterydophyta preferent to limestone habitats

ADIANTACEAE

Adiantum capillus-veneris L.
Adiantum caudatum L.
Adiantum caudatum var. *edgeworthii* (Hook.) Bedd.
Adiantum malesianum J. Ghatak

ANTROPHYACEAE

Antrophyum callifolium Blume

Zhu Hua 93011 (HITBC)

Li Yan-hui 8541 (HITBC)

Ch700 (SYS); *Ch932* (SYS); *Pei Sheng-ji* 10084 (HITBC)
Li Yan-hui 1696 (HITBC)

Ch1064 (SYS); *Cui Jing-yun* 19416 (HITBC)
Ch311 (SYS); *Tao Guo-da* 41641 (HITBC)
Ch168 (SYS); *Ch388* (SYS); *Ch359* (SYS); *Wang Hong* 1494 (HITBC)
Ch984 (SYS); *Wang Hong* 1484 (HITBC)
Ch381 (SYS); *Ch657* (SYS); *Li Yan-hui* 4210 (HITBC); *Tao Guo-da* 16090 (HITBC)
Cui Jing-yun 22793 (HITBC)

Ch468 (SYS); *Ch714* (SYS); *Pei Sheng-ji* 9359 (HITBC)
Ch844 (SYS)
Ch268 (SYS); *Li Yan-hui* 11915 (HITBC)
Ch507 (SYS); *Ch811* (SYS)
Ch463 (SYS); *Ch1054* (SYS); *Tao Guo-da* 9189 (HITBC)
Ch653 (SYS); *Ch616* (SYS)
Ch668 (SYS); *Tao Guo-da* 16447 (HITBC)
Ch654 (SYS); *Ch408* (SYS)

Ch1240 (SYS); *Wang Hong* 3066 (HITBC); *Tao Guo-da* 16049 (HITBC)
Li Yan-hui 4866 (HITBC)
Tao Guo-da 13661 (HITBC); *Zhu Pei-zhi* 8642 (HITBC)

Expedition 34430 (HITBC)
Li Yan-hui 2554 (HITBC)
Li Bao-gui 734 (HITBC)
Zhu Pei-zhi 8668 (HITBC)

Li Bao-gui 803 (HITBC)

Appendix 1. Continued.

ASPLENIACEAE

- Asplenium austrochinense* Ching
Asplenium excisum C. Presl
Asplenium interjectum H. Christ
Asplenium prolongatum Hook.
Asplenium saxicola Rosenst.
Asplenium varians Wall. ex Hook. & Grev.
Hymenophyllum cheilosorum (Kunze ex Mett.) Tagawa
Neottopteris antrophyoides (H. Christ) Ching

ATHYRIACEAE

- Allantodia alata* (Christ) Ching
Allantodia pinnatifido-pinnata (Hook.) Ching
Kuniwatsukia cuspidata (Bedd.) Pic. Serm.

BOLBITIDACEAE

- Egenolfa tonkinensis* C. Chr. ex Ching

DRYNARIACEAE

- Drynaria bonii* H. Christ
Drynaria fortunei (Kunze ex Mett.) J. Sm.
Drynaria rigidula (Sw.) Bedd.

DRYOPTERIDACEAE

- Dryopteris cochlaeta* (D. Don) C. Chr.
Polystichum deltodon (Baker) Diels

HEMIONITIDACEAE

- Pityrogramma calomelanos* (L.) Link

NEPHROLEPIDACEAE

- Nephrolepis auriculata* (L.) Trimen

POLYPODIACEAE

- Lepisorus bicolor* (Takeda) Ching
Lepidogrammitis rostrata (Bedd.) Ching
Lemnaphyllum microphyllum C. Presl
Lemnaphyllum carnosum (Wall.) C. Presl
Phymatodes cuspidata (D. Don) J. Sm.
Pyrrosia assimilis (Baker) Ching
Pyrrosia mollis (Kunze) Ching
Pyrrosia nuda (Giesenh.) Ching
Pyrrosia nummularifolia (Sw.) Ching
Pyrrosia subfurfuracea (Hook.) Ching
Pyrrosia tonkinensis (Giesenb.) Ching

Appendix 1. Continued.

PTERIDACEAE	<i>Pteris actiniopteroidea</i> H. Christ <i>Li Bao-gui</i> 921 (HITBC)
SELAGINELLACEAE	<i>Selaginella involvens</i> (Sw.) Spring <i>Selaginella pulvinata</i> (Hook. & Grev.) Maxim.
SINOPTERIDACEAE	<i>Aleuritopteris pseudofarinosa</i> Ching & S. K. Wu <i>Cheilosoria tenuifolia</i> (Burn. f.) Trev.
TECTARIACEAE	<i>Ctenitopsis devexa</i> (Kunze) Ching & C. H. Wang <i>Tectaria decurrens</i> (C. Presl) Copel. <i>Tectaria simaoensis</i> (Bedd.) Ching & C. H. Wang
THELYPTERIDACEAE	<i>Cyclosorus papilio</i> (Hope) Ching <i>Cyclosorus parasitica</i> (L.) Tardieu